Controversies Between Open and Closed Chain Exercises after ACL Reconstruction

Megan Bechtold, DPT, OCS, CMPT
Objectives

1. Understand historical perspectives that led to the era of open kinetic chain (OKC) avoidance in the presence of anterior cruciate ligament reconstruction (ACLR)

2. Discuss current literature and how this supports or refutes the avoidance of OKC exercise

3. Discuss evidence-supported recommendations for exercise prescription after ACLR
Take a poll
Benefits to Closed Kinetic Chain (CKC) Exercise after ACLR

- Reduce the anterior-directed forces that act on the tibia
- Increase tibiofemoral compressive forces
- Increase cocontraction of the hamstrings
- Mimic functional activities
- Less patellofemoral symptoms
A: No OKC

- **Avoidance** of open kinetic chain (OKC) exercise altogether

B: Partial OKC

- **Marginal** incorporation of OKC and/or **delayed** incorporation of OKC exercise

C: Full OKC

- **Immediate and consistent** use of OKC exercise throughout rehab
Historical Perspective
1970s-1980s

• “Gold Standard”
  – BPTB grafts with improving fixation and consistently good outcomes
  – Prolonged immobilization
  – Open chain quad exercises

(Davarinos, 2014)
1980s-early 90s

- Studies determine that the lower leg, when acted upon by the quadriceps femoris, is pulled anteriorly relative to the femur
  - 86% of that load is restrained by the ACL

Henning et al, 1985

• In vivo study using arthroscopy with strain gage
• Significantly less ACL strain with a partial squat than with a straight leg raise with 20#.

“We recommend that quadriceps exercises and testing by knee extension through a full range of motion not be done during the first year following ACL injury or reconstruction.”
Bynum et al, 1995

• Prospective, randomized study
• Aim: to determine if closed kinetic chain exercise is “safe” and if it “offers any advantages”

“As a result of this study, we now use the closed kinetic chain protocol exclusively after anterior cruciate ligament reconstruction.”
Mikkelsen et al., 2000

- Prospective, matched follow-up study
- Aim: to determine if CKC only versus CKC plus OKC training generates better outcomes after ACL reconstruction

“…the addition of OKC quadriceps training after ACL reconstruction results in a significantly better improvement in quadriceps torque without reducing knee joint stability at 6 months and also leads to a significantly higher number of athletes returning to their previous activity earlier…”
Perry et al., 2005

• Randomized, single-blind clinical trial
• Aim: to determine the effect of OKC vs CKC exercise on laxity and knee function in the ACL reconstructed knee

“OKC and CKC knee extensor training in the middle period of rehabilitation after ACLR surgery do not differ in their effects on knee laxity or leg function.”
Does OKC offer advantages to outcomes after ACL reconstruction?

Does OKC pose a threat to the reconstructed ACL?
Literature Update: Does OKC loading pose a threat to the ACL-reconstructed knee?
Heijne et al., 2007

- Prospective randomized outcome study
- Early OKC exercise with hamstring graft led to increased anterior laxity

“…early start of OKC quadriceps exercises after hamstring ACL reconstruction resulted in significantly increased anterior knee laxity in comparison with both late start and with early and late start [of OKC] after bone-patellar tendon-bone ACL reconstruction.”
Morrissey et al., 2009

• Aim: To determine which, if any, training factors are related to changes in anterior laxity scores after ACL injury or reconstruction.

“These results offer some early clinical support for increasing the strain on the anterior cruciate ligament graft...during rehab to promote decreased knee laxity.”
Barcellona et al., 2013

- Randomized controlled trial
- Decreased anterior laxity with high-load OKC exercise in ACLI patients

“…open kinetic chain resistance training at loads of 2 sets of 20RM led to a reduction in anterior knee laxity in the ACLI knee.”
Yes for OKC

No for OKC
Literature Update: Does OKC exercise improve outcomes?
Tagesson et al., 2008

- Randomized clinical trial
- Greater quadriceps strength was attained with OKC vs CKC exercise

“Rehab with OKC quadriceps exercise led to significantly greater quadriceps strength compared with rehab with CKC quadriceps exercise…Patients with ACL deficiency may need OKC quadriceps strengthening to regain good muscle torque.”
Beynnon et al., 2011

• Prospective, randomized, double-blind study
• No diff between OKC and CKC in long term outcome or laxity

“Rehab with either accelerated or nonaccelerated programs after ACL reconstruction with a bone-patellar tendon-bone autograft produces the same effect on clinical outcome, patient satisfaction, patient function and proprioception.”
Fukuda et al., 2013

- Randomized, controlled clinical trial
- No difference in **early vs late** initiation of OKC exercise

“Early open kinetic chain group reached the same findings in relation to pain decrease and functional improvement when compared with the late open kinetic chain group but showed a faster recovery in quadriceps strength.”
Yes for OKC

No for OKC
Systematic Reviews
Andersson et al., 2009

• 70 articles reviewed

“CKC produced less pain and laxity while promoting better subjective outcome than OKC after BPTB reconstruction.”
Glass et al., 2010

• 6 articles reviewed
• “CKC exercises alone were not found by any studies to be superior to OKC exercises.”

“…favorable results for utilization of both open and closed kinetic chain exercises for intervention with ACL deficient or reconstructed knees.”
Lobb et al., 2012

• 5 systematic reviews were reviewed

“There was moderate evidence of equal effectiveness of closed versus open kinetic chain exercise...”
And the winner is...
Yes for OKC

No for OKC
Recommendations
Recommendations

• Further research
• Consider the graft type, healing time and patellofemoral loading principles when implementing exercise after ACLR
• If implementing OKC exercise, consider incorporating a conscious hamstring co-contraction (Biscarini, 2014)
• Incorporate closed-chain eccentrics in the early phases of rehab to maximize strength potential (Gerber, 2007)
Thank you!
References


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References


Biscarini et al., 2014

• Descriptive lab study
• Hamstring co-contraction decreases anterior shear and may have rehabilitation implications when utilizing OKC exercise

“…intentional hamstring cocontraction may have the potential to be a safe and effective quadriceps-strengthening intervention in the early stages of rehabilitation…”